International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Association of Intrapartum Fetal Distress and Immediate Postpartum Foetal Acidemia: A Cross-Sectional Observational Study

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Abstract: ***Introduction: Asphyxia at birth is one of the leading perinatal causes of morbidity and mortality necessitating effective intrapartum monitoring of the fetus for its detection and prevention of neonatal acidemia. Abnormalities in cardiotocography (CTG) indicate fetal distress, which may progress to metabolic acidosis if not treated early. This study investigates the correlation between intrapartum fetal distress and postpartum fetal acidemia at early time, as measured by umbilical cord blood pH. Methodology: This cross - sectional observational study was conducted at RL Jalappa Hospital and Research Centre, Kolar. Pregnant women with cephalic presentation and gestation of more than 37 weeks were enrolled. Intrapartum fetal monitoring was performed by CTG, which was classified as normal, suspicious, or pathological. Neonates with pathological CTG were subjected to umbilical cord blood pH analysis, and pH <7.2 was considered to be indicative of acidemia. Neonatal outcomes information, including NICU admission and resuscitation needs, were extracted. Statistical analysis was done using SPSS, where p - value <0.05 was taken as significant. Results: Pathological CTG findings were strongly associated with lower umbilical cord blood pH (p=0.043), increased NICU admission (p=0.024), and adverse neonatal outcomes. The NICU admission rates was higher in male newborns (p=0.005). Fetal distress, resuscitation, and abnormal liquor characteristics were highly associated with NICU admission (p=0.002, p=0.004, p=0.000, respectively). Ventilated neonates or with complications such as sepsis and low birth weight were likely to need NICU (p=0.018). Conclusion: Abnormal CTG results have a strong association with neonatal acidemia and adverse outcomes. Early detection of fetal distress, timely intervention, and intensified fetal monitoring can potentially reduce neonatal morbidity and mortality rates.***

Keywords: Birth asphyxia, fetal distress, cardiotocography, neonatal acidemia, NICU admission, umbilical cord blood pH.

1. Introduction

Birth asphyxia is one of the major causes of perinatal morbidity and mortality; therefore, early diagnosis and proper management to prevent unfavorable outcomes in the infant are necessary. Accurate intrapartum fetal monitoring is likely the best option to minimize the dangers of birth asphyxia. Early identification of fetal hypoxia during labor may also prevent secondary acidemia and resultant long - term consequences. Neonatal acidemia from impaired oxygenation during labor can lead to severe consequences such as hypoxic - ischemic encephalopathy, developmental delay, and even neonatal death. Therefore, early intervention such as cesarean delivery or oxygen therapy is essential in high - risk fetal management. [1, 2]

Intrapartum fetal monitoring is generally achieved by a host of techniques such as cardiotocography (CTG), contraction stress tests, vibroacoustic stimulation, and fetal movement counts. Of these, the most employed process for ongoing assessment during delivery is CTG. It can detect patterns in abnormal fetal heart rate indicating fetal distress with a potential option for earlier intervention. It has been included in routine clinical care for detecting early with subsequent proper delivery of fetuses with adequate reserve for labor. CTG trace analysis is guided by clinical guidelines such as those of the National Institute for Health and Care Excellence (NICE), which guide clinicians to recognize pathological fetal heart rate patterns and adhere to the correct steps for intervention. [3, 4]

On suspicion of fetal distress based on abnormal CTG traces, further diagnostic workup in the form of umbilical cord blood pH analysis must be done to confirm the presence of acidemia in the fetus. Acidemia develops if the fetus has an inadequate oxygen supply, and tissue hypoxia eventually develops into metabolic acidosis. An excess of byproducts from metabolism, including lactic acid, causes a decrease in the pH of the umbilical artery, and it is a confirmatory test for fetal acidemia. Neonates with manifestations of acidemia must be promptly treated, by the administration of oxygen, in an effort to prevent the exacerbation of such complications as hypoxic - ischemic encephalopathy and other irreversible neurological damage. [4, 5]

Fetuses that are at increased risk of acidemia usually display abnormal CTG tracing patterns at the time of delivery. Women with conditions such as preeclampsia, diabetes, or intrauterine growth restriction (IUGR) are at increased likelihood of having fetuses that show pathological CTG features. These fetuses have a high risk of acidemia, so proper monitoring and early detection become necessary. Timely diagnosis of fetal distress on the basis of CTG after which it must be confirmed with umbilical artery pH analysis is necessary for making delivery - related decisions.

When fetal distress has been confirmed, cesarean section is usually the method of choice in a bid to spare further compromise to the fetus. But the basis for a cesarean section should be strict justification, given that the method carries inherent hazards to the mother, including excessive recovery and increased morbidity. [6, 7]

The correlation of abnormal CTG patterns indicating fetal distress with the subsequent discovery of acidemia within the umbilical artery pH is useful proof for the reliable diagnosis of acidosis in the fetus. This correlation aids clinicians in understanding mechanisms of fetal distress and gives improved predictions of neonatal outcome. By the identification of fetuses at risk for acidemia, healthcare professionals can implement early and effective treatments such as oxygen therapy and emergency cesarean delivery, thus reducing the incidence of neonatal morbidity and mortality. [8, 9]

The purpose of this research is to identify the relationship between intrapartum fetal distress, as evidenced through abnormal CTG patterns, and subsequent development of acidemia, as shown by umbilical artery pH analysis. This knowledge is essential in optimizing the high - risk pregnancy management protocols and enhancing neonatal outcomes. By understanding this correlation, we expect to give practical input on clinical management of fetal distress with the aim of preventing acidemia and its complications from occurring. In the long run, this research hopes to enhance the quality of maternal and infant care and reduce the occurrence of birth asphyxia and sequelae.

2. Methodology

This cross - sectional observational study sought to determine the association between intrapartum fetal distress, as identified by pathologic cardiotocography (CTG) tracing, and immediate postpartum fetal acidemia, measured as umbilical cord blood pH. The work was conducted at RL Jalappa Hospital and Research Centre, Kolar, involving pregnant women aged more than 37 weeks' gestation and cephalic presentation, who provided consent to participate in the study. Inclusion criteria were used to ensure that term pregnancies with appropriate fetal positioning only were considered to limit confounding factors such as multiple gestation or malpresentation. Pregnant women with less than 37 weeks of gestational age, a history of previous cesarean section, or other complicating factors were excluded from the study.

After enrollment, the pregnant women were subjected to continuous intrapartum fetal monitoring with cardiotocography (CTG) every second hour. CTG was interpreted based on the guidelines of the National Institute for Health and Care Excellence (NICE). CTG patterns were divided into normal, suspicious, and pathological. Pathological CTG, which points towards fetal distress, was followed by planned immediate delivery. The time interval from diagnosis of fetal distress to delivery was recorded, and the average time was approximately 45 minutes. During delivery, a sample of blood from the umbilical artery was drawn into a heparinized syringe for measurement. The pH of the blood sample was also recorded by an ABG analyzer, and below 7.2 pH was considered the value for acidemia.

In addition, neonatal outcomes were documented, including active resuscitation needed, NICU admission required, and APGAR score at 1 and 5 minutes post - delivery. These items provided further insight into the relationship between CTG - diagnosed fetal distress and associated neonatal health outcome. Further investigations or treatment needed for the neonate, e. g., oxygen therapy or other therapeutic intervention, were recorded as well for overall analysis.

Statistical Analysis: The data collected were keyed into Microsoft Excel for tabulation and analyzed using SPSS software. The demographic and clinical descriptive features of the participants were described using descriptive statistics for which qualitative data were reported as frequencies and percentages. For the comparison of categorical variables, the chi - square test was used. Continuous variables were described as means and standard deviations and compared using the t - test in examining differences between groups. A p - value less than 0.05 was considered statistically significant, indicating a significant correlation between fetal distress (as detected by CTG) and postpartum acidemia. Statistical analysis determined the strength as well as significance of the relationship between abnormal patterns of CTG and the occurrence of acidemia and the resulting neonatal outcomes.

3. Results

The comparison between data for the Suspicious and Pathological NST groups revealed several intriguing findings. The age gap between the two groups was not statistically significant (p - value = 0.164). Also, upon examining the umbilical cord blood pH, a faint yet discernible discrepancy between the groups was observed with the Pathological group showing lower pH (mean = 7.26, p - value = 0.043), reflecting a higher frequency of acidemia among babies with pathological NST results. These findings suggest that abnormal NST patterns in pathology are associated with worse neonatal outcomes, including increased NICU admission and worse acidemia. (Table 1)

Table 1: Comparison of Demographic and Clinical Variables Between NST Groups

Age Comparison between NST Groups	NST Group	N	Mean	Std. Deviation	P - Value
	Pathological	27	31.04	39.78	0.164
	Suspicious	23	24.52	4.32	
ABG - pH Comparison between NST Groups	Pathological	27	7.26	0.061	0.043
	Suspicious	23	7.27	0.046	

The study found a significant correlation between NST findings and NICU admission (P = 0.024), with a higher proportion of neonates with pathological NST patterns requiring NICU treatment, illustrating the predictive value of

NST in identifying fetuses at risk. In addition, male neonates also demonstrated a significantly higher NICU admission rate than females (P = 0.005), suggesting a potential biological vulnerability to increased perinatal morbidity in males, potentially due to differences between lung maturity and stress response in males. These findings demonstrate the importance of fetal surveillance with NST and warrant further studies to elucidate the mechanisms for these associations. (Table 2)

Table 2: Association of NST Results and Neonatal Sex with NICU Admission

	NST	No	Yes	Total	P value
NST by NICU Admission	Pathological	15	12	27	0.024
	Suspicious	14	8	23	
Sex of Baby by NICU Admission	Female	11	9	21	0.005
	Male	18	11	29	

Distribution of NICU admission based on obstetric history and diagnosis did not reveal any statistically significant correlation between the category of obstetric history and the need for NICU admission (p - value = 0.658). Although the Primi group (primiparous women) revealed a higher number of women requiring NICU admission (11 out of 34), no statistical difference was observed in other obstetric categories such as G2A1, G2P1D1, G2P1L1, etc. The total cohort size was 50, out of which 29 did not need NICU stay and 20 needed NICU admission. Based on these findings, it was seen that obstetric history had no significant impact on NICU admission probabilities within this cohort. (Table 3)

Table 3: Diagnosis by NICU Admission

Diagnosis	NICU = No	NICU = Yes	Total	P value
G2A1	2	1	3	0.658
G2P1D1	2	0	2	
G2P1L1	2	3	5	
G2PL1	0	1	1	
G3P1L1A1	0	3	3	
G3P2L2	1	0	1	
G4P3L2D1	0	1	1	
Primi	22	11	34	
Total	**29**	**20**	**50**	

The study identified a high correlation between delivery indications, resuscitation requirements, and POF (Presence of Findings) with NICU admission. Fetal distress, more often with or without meconium - stained liquor or with LSCS previously, was the common indication for NICU admission (P = 0.002). Requirement for resuscitation was also independently related to NICU admission (P = 0.004) since most neonates requiring positive pressure ventilation (PPV) or more than three breaths of resuscitation were admitted. In addition, abnormal POF findings such as thick meconium - stained amniotic fluid, absence of liquor in the case of fetal distress, and thinning of the lower uterine segment were significantly associated with NICU admission (P = 0.000). The results emphasize the necessity of increased fetal surveillance as well as urgent obstetric intervention to reduce neonatal morbidity. (Table 4)

Table 4: Indication, Resuscitation Required and POF by NICU Admission

	Indication	NICU = No	NICU = Yes	Total	P value
Indication	Breech with fetal distress	0	1	1	0.002
	Fetal distress	22	14	36	
	Fetal distress with meconium stained liquor	2	1	3	
	Previous LSCS with fetal distress	2	1	3	
	Previous LSCS, fetal distress	0	1	1	
Resuscitation Required	Immediate Care	0	1	1	0.004
	No	27	6	33	
	PPV	0	1	1	
	Yes	2	12	14	
POF	Liquor reduced	2	0	2	0.000
	Liquor clear and excess	0	1	1	
	Liquor NIL, baby smeared with meconium	1	1	2	
	Liquor NIL, LUS thinned out	0	1	1	
	Liquor thick meconium stained liquor	0	2	2	
	LUS thinned out, meconium flakes, loop of cord	0	1	1	
	Normal	15	0	15	

The study observed a strong correlation between admission to NICU and neonatal outcomes (P = 0.018). While one baby who was considered healthy did not require any treatment in NICU, most of the neonates admitted were for complications for which they required respiratory support such as CPAP or HFNC, oxygen supplementation, or for the treatment of diseases such as LBW and sepsis. Surprisingly, five neonates required oxygen therapy, and one was on mechanical ventilation for sepsis. These findings strengthen the central role of NICU in the management of newborn complications and highlight the need for early detection and intervention to maximize the outcome of neonates. (Table 5)

Table 5: Neonatal Outcomes by NICU Admission

Neonatal Outcomes	No	Yes	Total	P value
Baby healthy	1	0	1	0.018
CPAP tapered, asphyxia	0	1	1	
HFNC, tapered to NP and given mother side	0	1	1	
NICU for LBW care	2	5	7	
O2 supplementation	0	5	5	
O2 supplementation, antibiotics	0	1	1	
On MV, sepsis	0	1	1	
Total	29	20	50	

4. Discussion

Our study demonstrated a strong association between pathological cardiotocography (CTG) patterns and

immediate postpartum fetal acidemia, as indicated by lower umbilical cord blood pH. This is consistent with findings from previous research, which also showed that abnormal CTG traces are predictive of neonatal complications, including metabolic acidosis and adverse neonatal outcomes. The association of the pathological CTG findings with acidemia confirms the justification for early labor interventions that can improve neonatal outcomes. In our research, we found that neonates with a pathological CTG pattern also had lower pH level values, confirming the prognostic value of CTG in terms of acidemia ($p = 0.043$). This supports the findings of Kanagal et al. (2022), who reported a similar relationship between pathological CTG patterns and pH levels < 7.2. They emphasized that Subjects with pathological CTG had more babies with low cord pH compared to suspicious CTG (62.6 vs 26.4%).55% of babies with pH <7.2 needed neonatal intensive care unit (NICU) admission compared to 11.6% with normal pH. Babies born with pathological CTG and low cord pH were more likely to have NICU admission and other morbidities. [10]

In our study, the neonates with pathological CTG patterns required increased NICU admission ($p = 0.024$). This finding corroborates the results of Banu et al. (2015) [11], where 73.9% of those with suspicious CTG and 81.8% with pathological CTG underwent cesarean section. But among them, only 20.5% neonates with pathological CTG needed resuscitation suggesting that though CTG may show abnormalities, all may not need resuscitatory measures. In our study, 30.2% of the newborns with nonreassuring CTG needed NICU admission. In a study by Indiramani et al. (2018) in their study found NICU admission rate of 55.9% in neonates of mothers with abnormal CTG pattern as against 1.7% in normal CTG patterns. [12]

Interestingly, we also found that male neonates had a higher rate of NICU admission ($p = 0.005$), which supports Lau et al. 's (2012) result. Male fetuses in the study conducted by Lau et al. (2012) were more susceptible to develop distress in labor [13]. This study also ascertained that male neonate had significantly higher NICU admission rate (male: 11/29, female: 9/21), and this also bears evidence to the biological vulnerability of male fetuses. This revelation warrants further monitoring and intervention of male neonates with abnormal CTG outcomes. But in the study by Paladugu et al. (2023), no significant difference existed between either gender who got acidosis [14]. This discrepancy can be attributed to our small population size, hence larger studies are essential for more proper results.

In our study, the ABG - pH of umbilical cord blood in the two NST groups, namely, Pathological and Suspicious, was compared and was found to be statistically different. While the pathological group mean pH was 7.26 with a standard deviation of 0.061, the suspicious group presented a slightly higher mean pH of 7.27 with a standard deviation of 0.046. The p - value for this comparison was 0.043, which is statistically significant. This suggests that the pathological NST group had a higher likelihood of developing acidemia, as indicated by the lower umbilical cord blood pH. In a study by Aboulghar et al. (2013), [15] where they found acidosis in 50% cases with pathological CTG and in 19.2% cases with suspicious CTG thus concluding that pathological rather than suspicious CTG significantly increased the risk of abnormal cord blood pH.

In the study by Ray and Ray et al. (2017) [16] the mean cord blood pH was 7.253 ± 0.07. With a pH of 7.2 as the cut - off for metabolic acidosis, 18.3% of neonates were found to be acidotic. They also found that among subjects with abnormal intrapartum CTG, 52.5% had acidosis and hence a statistically significant association was found between intrapartum CTG and umbilical cord arterial pH. In another study by by Abbasalizadeh et al., (2015) [17], 38.9% of infants with nonreassuring CTG patterns had pH less than 7.2 and the remaining 61.1% infants had pH more than 7.2. All infants were discharged in good health.

The role of meconium - stained amniotic fluid in predicting adverse neonatal outcomes was emphasized in our study. We found that fetal distress accompanied by meconium - stained liquor was significantly associated with NICU admission ($p = 0.002$). This finding supports the study by Parween S et al. (2022), who observed that Among 100 MSAF cases, 20% had grade 1, 22% had grade 2, and 58% had grade 3 MSAF. Most were primigravida, over 25 years old, with 47% having high - risk factors and 50% showing non - reassuring fetal heart rates. LSCS was more common in the MSAF group (49%) than in the non - MSAF group (37%). NICU admissions (30% vs.13%) and adverse neonatal outcomes (22% vs.12%) were higher in the MSAF group. Meconium aspiration syndrome occurred in 14%, with two neonatal deaths due to birth asphyxia, while one neonatal death in the non - MSAF group was due to sepsis. However, statistical analysis showed no significant difference in neonatal outcomes between the groups ($p < 0.001$). [18]

Our study also demonstrated a significant association between the need for resuscitation and NICU admission ($p = 0.004$). Neonates who required resuscitation, such as positive pressure ventilation (PPV) or multiple breaths of resuscitation, were more likely to be admitted to NICU. Similarly, Peers de Nieuwburgh M et al. (2024) found that among 202 infants who received PPV at birth, NICU admission was significantly higher in the ventilation cohort (33%) compared to controls (1.5%), $p \leq 0.0001$. Post - delivery complications were also more frequent in ventilated infants (45% vs.15.8%), with a higher risk observed in those receiving >1 min of PPV (52.8%) compared to ≤1 min (32.5%), $p = 0.002$. Additionally, ventilated infants had increased rates of antibiotic exposure, hypoxic - ischemic encephalopathy, respiratory support, and pneumothorax. [19]

In addition, we observed that neonates requiring mechanical ventilation or oxygen therapy due to conditions like low birth weight (LBW) and sepsis were more likely to require NICU stay ($p = 0.018$). Similarly, Meier A et al. (2022) [20] reported that oxygen therapy, CPAP, and mechanical ventilation were utilized in 13.3%, 41.1%, and 14.4% of cases, respectively. Median NICU stay was 12 days, with a 11.1% mortality rate. There was a high correlation between mechanical ventilation and the variables of gestational age <28 weeks, lower maternal age, LBW, low Apgar score, and neonatal mortality.

Although our investigation uncovered some critical results, we acknowledge one drawback of our study design. The investigation was conducted in one institution, which may limit the generalizability of our results. Additionally, although we highlighted CTG and umbilical cord blood pH as the major indicators of fetal distress, future studies may investigate other biomarkers, such as lactate level and base deficit assessment, to have a more comprehensive appraisal of neonatal acidemia.

5. Conclusion

Our study attests to the utility of unbroken CTG monitoring during labor and its role in identifying fetal distress and predicting neonatal acidemia. The strong correlation between pathological CTG tracings and lower umbilical cord pH values attests to the need for immediate intervention in at - risk pregnancies. Our findings complement clinical practice guidelines for close monitoring of fetuses with atypical CTG patterns and immediate obstetric intervention to minimize neonatal morbidity and mortality. Larger sample size multicenter trials in the future are required to validate these findings and individualize protocols for fetal monitoring and neonatal care.

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